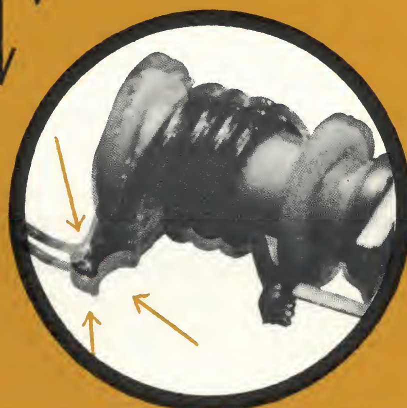
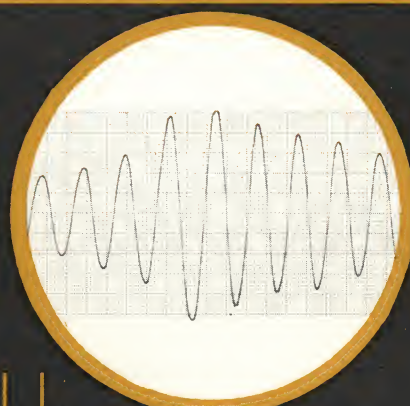
CHADWICK
HELMUTH
COMPANY, INC.

MECHANICAL AMPLIFICATION AT RESONANCE IS DESTRUCTIVE

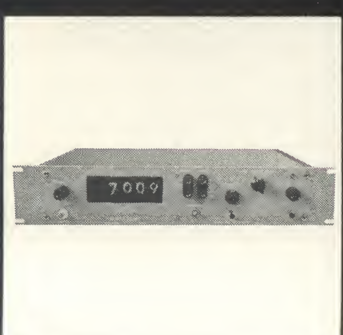
SEE IT



MEASURE IT



WITH SLIP-SYNC® INSTRUMENTATION



VMS RECORDING, DIGI-MARK, PHASE CONTROL, SWEEP-SYNC
VISUAL AND PHOTOGRAPHIC
THEORY

STROBOSCOPIC SAMPLING THEORY

Visual, photographic, and oscillographic applications of the SLIP-SYNC® and VMS® systems all rely on automatic stroboscopic sampling. When a cyclic event at varying frequency "f" is continuously sampled at tracking frequency "f − Δf" an exact replica of the original event is created at fixed slow-motion frequency "Δf." Chadwick-Helmuth instruments apply this principle in several different ways:

USE	EVENT	SAMPLING DEVICE
Visual slow-motion study	Cyclic physical motion (as vibration, rotation)	Short duration, high intensity strobe flashes.
Slow-motion movies	Cyclic physical motion (as vibration, rotation)	16 mm film frames, synchronized to the strobe.
Oscillograph recording of variable high frequency transducer signals	Electrical signal from vibration, pressure, strain, or other transducers	"Sample/hold" electronic circuit.

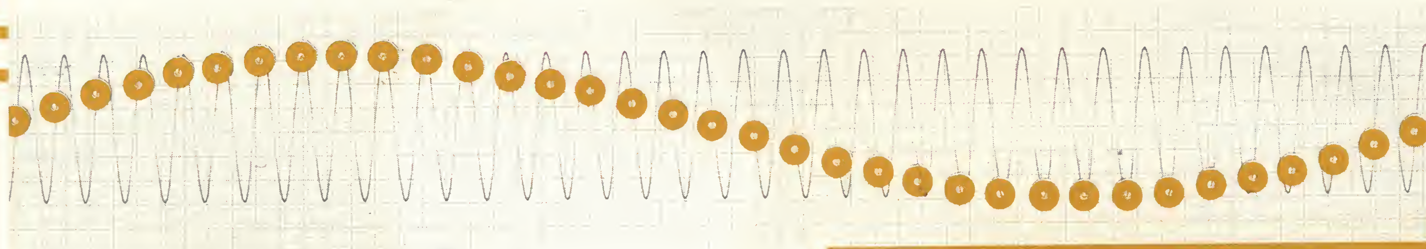


FIGURE 1

Figure 1 shows a high frequency sine wave. The dots on the signal indicate samples from successive cycles. "Smoothing" the points from this sampling creates an exact low frequency replica of the high frequency signal. In the case of the visual and photo strobe systems the eye and brain receive, "hold," and "smooth" the sample points. In the electrical analog, or VMS system, these same functions are performed electrically. Figure 3 shows a visual and photographic SLIP-SYNC system. Figure 2 shows the block diagram of a three channel "VMS" system.

In a typical application, such as a sine wave vibration test, shaker frequency "f" goes to the SLIP-SYNC instrument, which subtracts a constant difference frequency "Δf," nominally 1 cps. This "f − Δf" tracks the event frequency but is 1 cps less. The sine wave at "f − Δf" is converted to pulses and

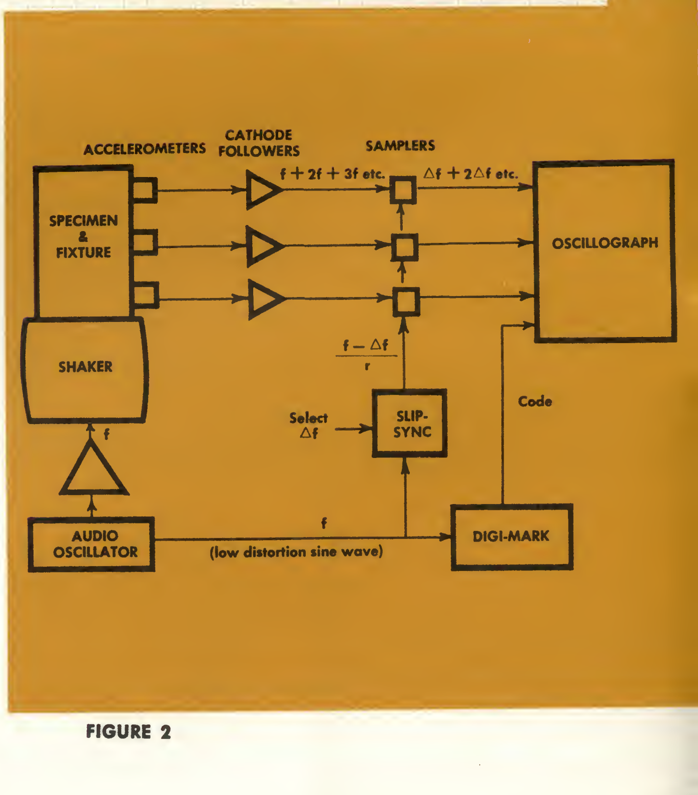


FIGURE 2

FIGURE 5

commands the sampling device. The slow-motion replica that is then created stays at the fixed low frequency "Δf" even though "f" is sweeping.

Because of pulse rate limitations of the sampling devices, it is necessary to "count-down," or sample every-other (or every-n-th) cycle of the event at high test frequencies. The SLIP-SYNC instrument automatically selects the proper divisor, integer "r", and yields the command pulse in the form $\frac{\text{"}f - \Delta f\text{"}}{r}$ where "r" is 2 for sampling every other cycle, or n for sampling every n-th cycle. This division makes no change in the slow-motion effect. Visual strobe and VMS operation are flicker free with a maximum sample rate of about 200, and can be used simultaneously. The PULSE CAMERA should operate about 24 samples per second, which is projector rate. The screened pictures then yield slow-motion very near that seen visually at the time of test. However, a 24 sample per second rate is too slow for the VMS, so the VMS and PULSE CAMERA should not be used simultaneously. Figure 4 shows "r" changing from 1 through 10, while the shaker frequency sweeps from 10 to 1000 cps, to achieve a maximum sample rate of 100 per second.

"Δf" can be set at any value between 1/3 and 3 cps. A switch on the SLIP-SYNC instrument can also give a "Δf" of zero, which "freezes" the stroboscopic image, and makes the object appear stopped. A "Phase Position" control then permits "freezing" this image at any point in the cycle. Figure 5 is a double exposure photograph of a shock mount in resonance. Vibration axis is horizontal, and the two exposures were made precisely at peak deflection. Input displacement is indicated at a corner of the fixture, and response displacement is very evident on the connector and the mount. Q is 10.

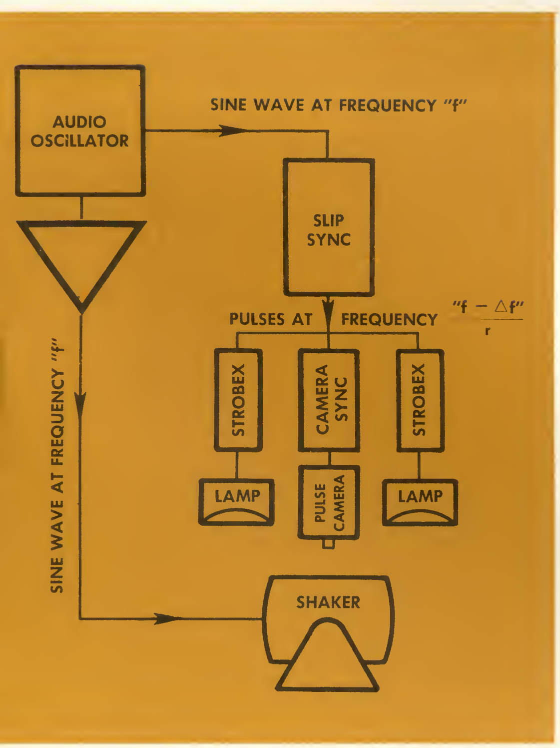


FIGURE 3

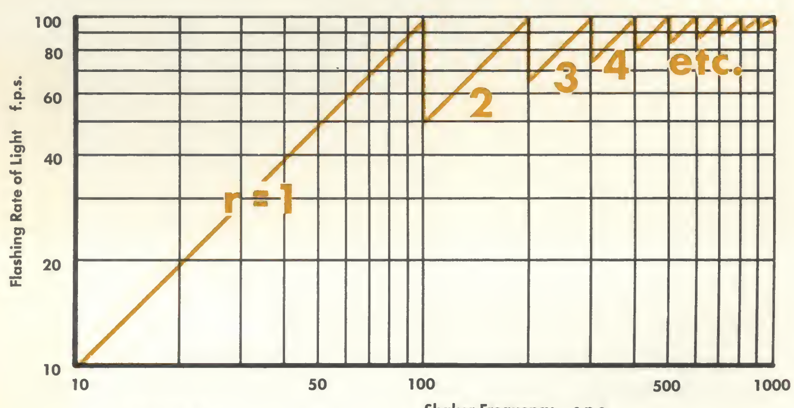


FIGURE 4

Note that this sampling technique applies only to cyclic or repetitive events. However, the event need not be sinusoidal. Slow-motion replicas will be accurate on highly distorted signals, and "Δf" will double for second harmonic, treble for third harmonic, and so forth. Stroboscopic sampling is not effective on random noise tests, or shock tests. However, it has considerable use on combined sine/random tests when the random portion is 25% or less.

VISUAL STUDIES

USE THE SLIP-SYNC AND STROBEX TO DETECT AND STUDY RESONANCES

Over half of flight failures are caused by vibration, and most vibration failures are the direct result of mechanical amplification at resonance. At critical frequencies, resonant areas have acceleration levels many times those introduced by the environment. Good product design requires testing and modifying every structure for all frequencies appropriate to the application until no high Q resonances remain.

SLIP-SYNC systems create a continuous and automatic slow-motion image of high frequency vibration, particularly effective in laboratory work with vibration exciters. Resonant mode shapes and phase relations are quickly detected and easily analyzed. Small displacements, otherwise invisible, are clearly seen. All visible points of the specimen are "instrumented" in all axes. No other monitoring method approaches the convenience, completeness, or the speed of the SLIP-SYNC system.

The stroboscopic image can also be "frozen" at any point in the vibration cycle. Freezing at the extremes of motion permits measurement of peak-to peak amplitude with a scale, microscope, or telescope. Input "g" can be read by accelerometer. By measuring displacement at the point of interest and knowing frequency from the shaker, response "g" can be calculated. This allows determination of amplification factor "Q" at points where an accelerometer can not be attached. Freezing at the extremes of motion also permits single and double exposure pictures of resonant mode shapes with ordinary still cameras (see Fig. 5). In addition, it offers increased speed and accuracy in the displacement calibration of accelerometers, in conjunction with measuring microscopes. Once zero is determined, phase angle of frozen images can be read to 5°, for studies of cyclic mechanisms or phase measurements in vibration work. Application bulletins with full details are available on request.

USEFUL FREQUENCY RANGE

Visual strobe effects can be used as low as 5 and 10 fps, but "flicker" is annoying. Good images appear at 20-25 fps, and they become increasingly smooth until 50 fps appears as continuous light.

Without optical assistance, the useful upper frequency of the SLIP-SYNC system is displacement limited at about .005". Thus, the upper frequency limit depends on input "g" levels and on the amplification factor "Q" of the resonances that are excited. For instance, with 20 g input and Q of 25, resonances will be seen with the naked eye at frequencies up to 1,400 cps. Note that SLIP-SYNC systems are not limited in detection *of resonance* when input vibration falls below .005". In fact, they are then most valuable and necessary. When telescopes and microscopes are convenient, the displacement limitation drops to about .0005", thus greatly extending the useful upper frequency limit.

SLOW-MOTION MOVIES

16mm MOTION PICTURES DRAMATIZE DESTRUCTIVE RESONANCES WHERE WORDS AND GRAPHS FAIL

ADDITION OF A PULSE CAMERA TO A SLIP-SYNC SYSTEM BRINGS THESE BENEFITS

Increase lab efficiency. Tests need not be held up or repeated for witnesses.

Avoid specimen fatigue from repeated tests.

Capture failure modes on deliberate or accidental tests to destruction.

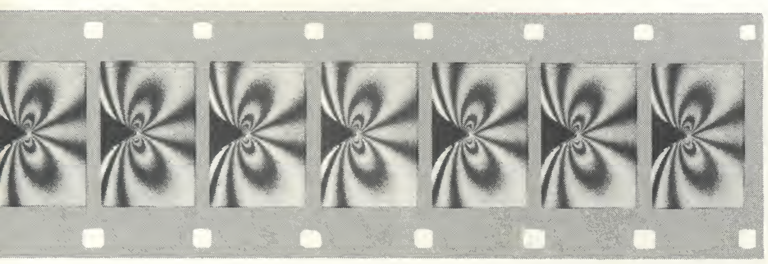
Instrument every visible point of the specimen, with a permanent record.

"See" tests too hazardous to watch first hand.

Communicate effectively via color film with designers, vendors, customers, or the services.

While the SLIP-SYNC system does not replace the "high speed" camera on transient events, it gives excellent performance on cyclic events where the "high speed" camera has many shortcomings:

ITEM	SLIP-SYNC SYSTEM	HIGH-SPEED CAMERA
Shooting time for 100′ roll	Approx. 3 minutes (film speed about 24 fps)	1/2 to 4 seconds (film speed to 8,000 fps)
Stop and start camera during test	OK	NO
Highest event frequency for 1 cps slow-motion	10,000 cps	333 cps for 8,000 cps camera
Keep slow-motion rate constant while event frequency sweeps	OK	No, camera speed cannot be reasonably synchronized to event.
Cameraman sees event in slow-motion before, during, and after filming.	YES	NO
Chance of photographing a random event (as a failure)	Good, with long shooting time.	Nil
Exposure and lighting	F-stop for any setup easily determined from nomograph; ample light for color film.	F-stop changes with camera speed; hot brilliant lights required; usually limited to grainy black and white film.



It is now possible to use photoelastic coatings for the study of dynamic problems. SLIP-SYNC controlled STROBEX lights allow visual analysis of the strain patterns, and the PULSE CAMERA permits effective color photography of the "fringes." Fine still pictures can be made by using a still camera and the Phase-Position control of the SLIP-SYNC.

VMS® OSCILLOGRAPH RECORDING

Phase relations, waveshape, and *amplitude* are the three essentials to analysis and understanding of accelerometer data from sinusoidal vibration tests. The recording oscillograph cannot give this information by direct recording of the accelerometer signal because:

1. Paper speed in inches/sec must be close to shaker frequency in cps, and should track shaker frequency as it sweeps. However, paper speed cannot be changed readily, nor can it track.
2. The fastest paper speeds available cannot adequately stretch out signals above 300 cps.
3. Even at low shaker frequencies, paper consumption and cost is great, and voluminous data defies data reduction.

The "VMS" ("Vibration Measuring System") for the first time permits continuous and automatic oscillograph recording of these three essentials. It changes raw data sweeping from 10 cps to 10kc into a fixed, low frequency replica. Any replica frequency from 1/3 to 3 cps can be selected, and directly connected to oscillograph galvanometers. The oscillograph can then be run at economical low paper speeds, and total length for complete continuous recording of a test is quite reasonable. Visual monitoring for "quick look" at phase, distortion, and amplitude is easy. The galvos or pen motors can be observed, or multi-channel displays can be made on single beam oscilloscopes by further switching with the DATA-SWITCH. The DIGI-MARK® further enhances oscillograph data. It drives one galvo placing shaker frequency to four significant figures on the edge of the record every other second.

Phase is a powerful tool in vibration testing. Vibration is a vector quantity, requiring phase and amplitude for complete definition. Phase is essential to calculation of stress between two instrumented points. Two points in-phase with similar "g" create little stress, where 180° out of phase with the same "g" may be destructive. 90° phase shift of response from input defines resonance, and is particularly necessary to determine resonance in a damped system. Phase is critical in work with mechanical impedance, which is the vector of force divided by velocity. Phase shift between accelerometers with sensitive axes *parallel* can also warn of cross-motion.

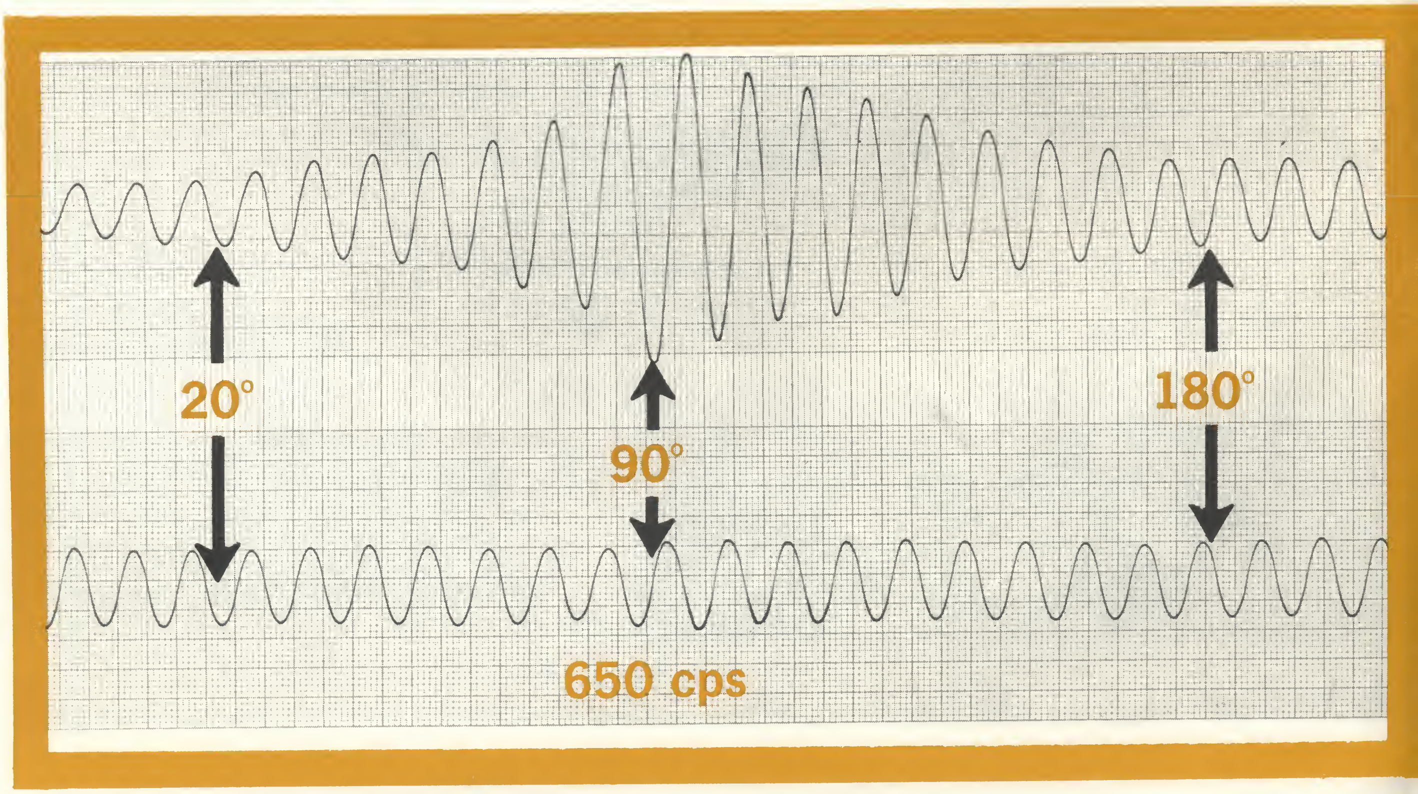
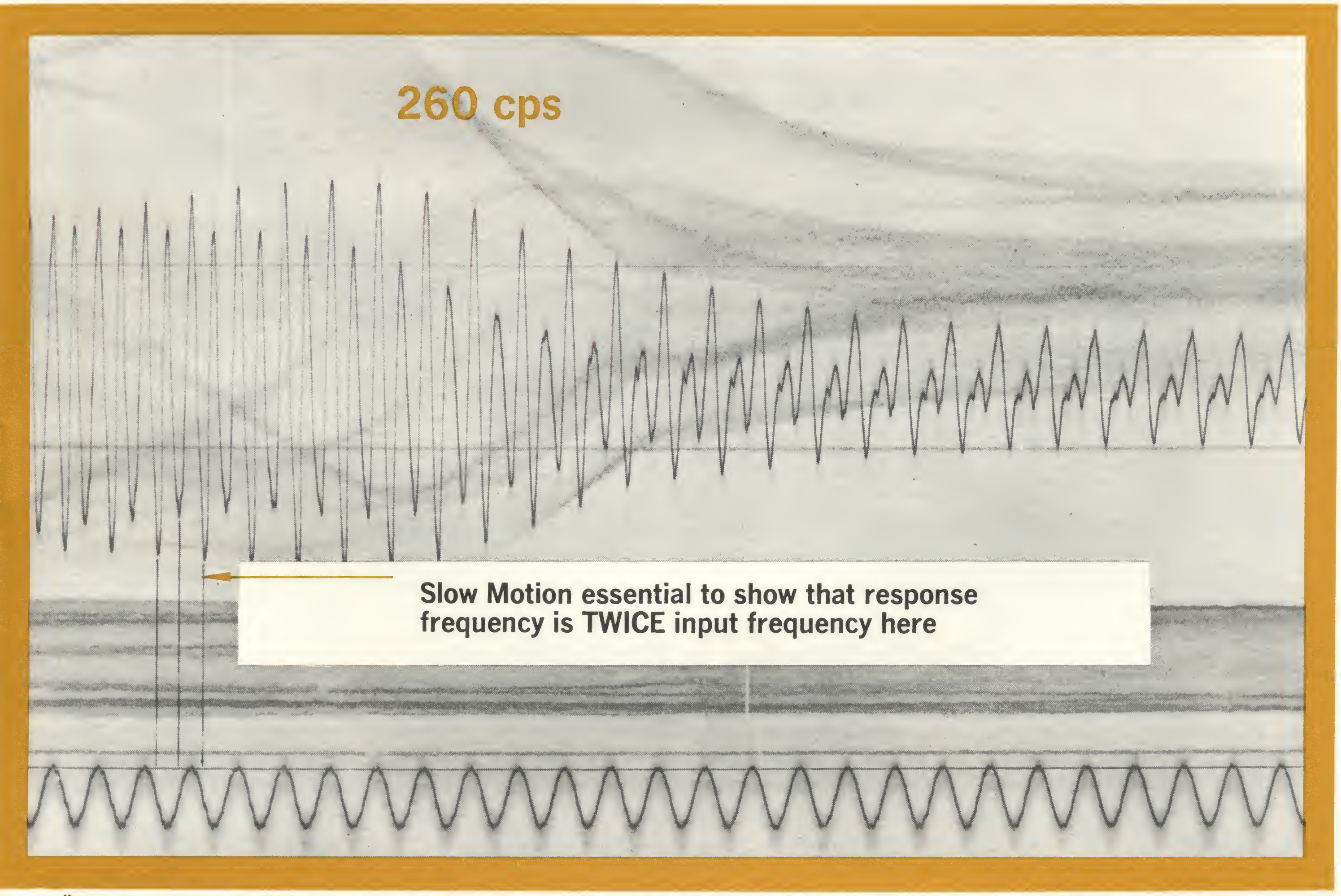


FIGURE 6

Figure 6 shows two accelerometer signals on a sweep from 600 to 700 cps, converted via "VMS" to a fixed 1 cps, and given to a direct-writing recorder. The lower trace gives input to a fixture, and the upper trace shows response from another point. Note how closely this record follows the classic conditions: in-phase below resonance, 90° out at resonance, and 180° out above resonance.

Distortion is an oft-overlooked problem in vibration testing and analysis. High "Q" resonances in the test will respond to the *harmonic content* of the shaker system, amplifying it until it may exceed the fundamental. Non-linear resonances can also generate distorted responses. In any sinusoidal vibration test there will be frequencies where "g" readings are meaningless because they consist of several frequencies, usually harmonically related. Figure 7 shows a short section of an optical oscillograph record from the evaluation of a sheet metal chassis on a sweep approaching 260 cps. There are four traces evident, from two accelerometers. One accelerometer is located at the input and the other where response is maximum. Each accelerometer has been recorded directly *and* via "VMS." There is a hint of distortion trouble from the gray bands and shading in both the direct recording traces. The "VMS" slow-motion traces make interpretation of this distortion simple and easy.* That in the lower trace (input accelerometer) is a very high harmonic of low amplitude and of little interest. The distortion in the response trace, however, is gross. The fundamental now appears in the response trace as amplitude modulation on the complex waveshape. At the right side of the illustration a heavy percentage of second harmonic is evident from the waveshape. This second harmonic builds up towards the left of the illustration until it is about five times the amplitude of the fundamental. Note that there are now two cycles of response for one cycle of input. The resonance which is responsible for this is at 520 cps and not 260 cps!



* Ask for a copy of Bulletin 11, "Understanding Waveshapes."

FIGURE 7

DIGI-MARK®

DESCRIPTION

The DIGI-MARK is a conventional electronic counter, with an important extra feature: The staircase voltages from each of its decades are wired to an electronic programming switch. The DIGI-MARK counts (usually the audio oscillator signal from the console of the test equipment) for 0.1 or for 1.0 seconds, and then locks for readout for a minimum of one second. While the counter is locked, the electronic programming switch connects the single output jack for 0.2 second to each of the staircase voltages. The sequence of switching is "thousands" decade first, then "hundreds" decade, then "tens," and finally "units." When an oscillograph galvanometer is connected to this output jack, the four step deflections that it receives are easily read from the record as the digital number which the counter held.

While the counter is counting, the electronic programming switch connects zero volts to the output jack, so that the galvanometer records a base line. While the counter is locked, the staircase is connected to the output jack, and may be chopped at 60 cps with the zero reference, so that this base line continues on the readout portion of the record, for convenience in scaling each of the digits recorded. A switch permits the DIGI-MARK to record *without* chopped readout, if preferred.

A typical "calibration" trace before a test, and a typical trace during a test, follow:

CALIBRATION

While the "calibrate" button is depressed . . .

1) the input to the counter is disconnected,
2) 60 cps line frequency is connected instead,
3) the time base gate is held open, and,
4) the output is connected to the "staircase" from the tens decade.

The result is a "staircase" on the record, defining for that test setup the deflection for each of the digits from 0 to 9.

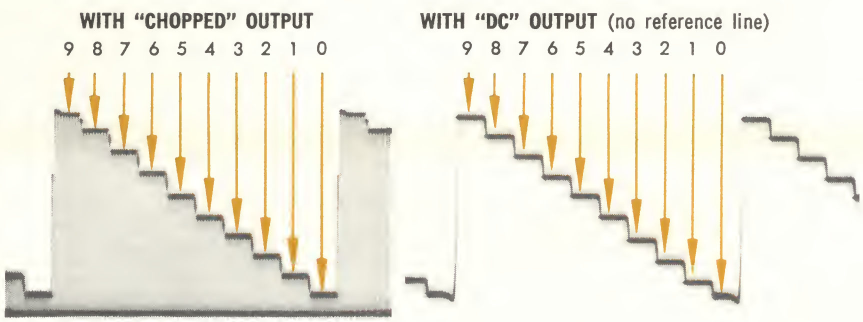


FIGURE 8

TYPICAL TEST RECORD

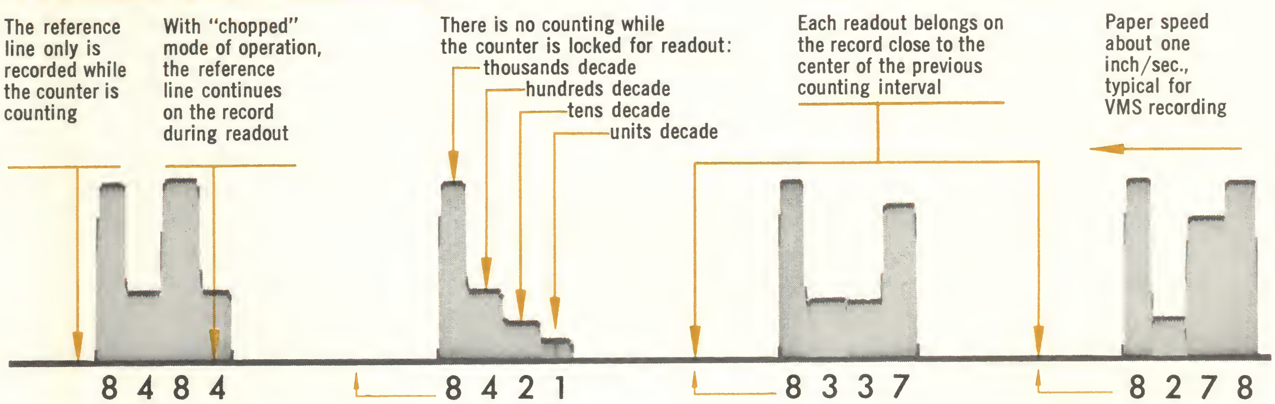
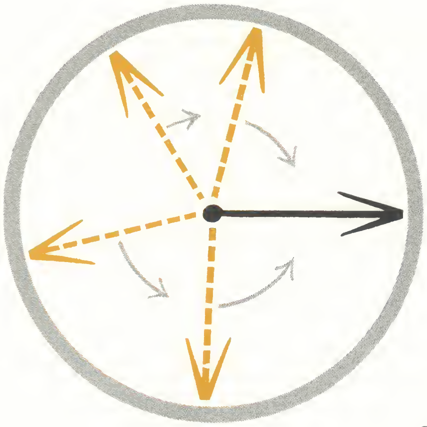


FIGURE 9



AUTOMATIC PHASE CONTROL SYSTEMS

Very large specimens are best subjected to vibration testing by use of two or more exciters, each with its own power amplifier. Fixture and shaker limitations make very large specimens difficult to excite with single large shakers. However, multiple shakers can never be precisely identical, and they can never "see" identical mechanical impedances where they attach to the fixture and specimen. These inequalities would make gross phase shifts occur between different drive points on the specimen, at frequencies where nearby resonances are set off.

Chadwick-Helmuth "Automatic Phase Control Systems" insure that desired phase relations are continually maintained at the drive points, in spite of these resonant effects and any other differences in the shaker systems. The "APC" inputs are amplified accelerometer signals from the chosen drive points. Analog computer multiplication techniques are used to detect phase differences of these feedback signals on the *fundamental only*. These error signals go to a servo driven phase shifter, where the oscillator signal going to the power amplifier of each shaker is phase shifted as necessary to keep the feedback signal locked to the reference oscillator. Thus, all shakers are kept at the desired phase relation to each other.

Other important features of Chadwick-Helmuth Phase Control Systems include:

High accuracy. . . .	(2° static error)
Fast response. . . .	(corrects at speeds to 180°/second)
Wide control range. . . .	(no blind spots, no stops)
Any phase relations. . . .	(desired phase relations between shakers can be preset to any angle between 0 and 360°)
Amplitude control	(easily adapted for amplitude control on *fundamental only*)

SWEEP-SYNC®

The SWEEP-SYNC is an oscilloscope accessory. It automatically locks sweep time of the oscilloscope to the period of test signals. Distortion and phase shifts are then easily detected and studied for sweeping or fixed frequencies in its range of 5 to 20,000 cps.

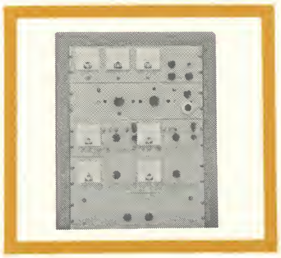
SWEEP-SYNC automation is important whenever frequency is changed often. It is vital when frequency is continuously changing over a broad band. In vibration tests, for instance, resonances occur in very narrow frequency bands. To see distortion and phase shift in accelerometer outputs, the oscilloscope must ALWAYS present an intelligible display. Resonances with distorted waveshape may occur in a bandwidth of a few cycles, and even IF the operator knew they existed he still could not respond to readjust oscilloscope controls. SWEEP-SYNC displays automatically locate all waveshape changes and phase shifts in accelerometer outputs.

SLIP-SYNC

generates stroboscopic sampling commands for strobe observation, photography, or "VMS" sampling.

PULSE CAMERA

creates slow-motion movies upon command of the SLIP-SYNC. It adapts readily to time-lapse, CCTV, CRO, and photography of other visual data displays.

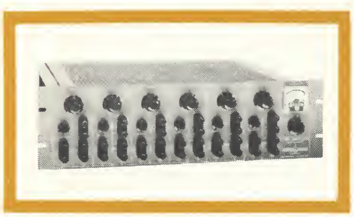


MULTIPLE SHAKER CONTROL SYSTEMS

take feedback signals from each drive point and adjust oscillator signals to respective shakers so that desired phase relations are maintained where multiple shakers excite one specimen.

ACCESSORIES

ROLLING CONSOLE, LAMP STAND, TRIPOD, REFLECTOR EXTENSION, RACK-OVER, and other accessories are provided for convenience or added performance of these instruments and systems.

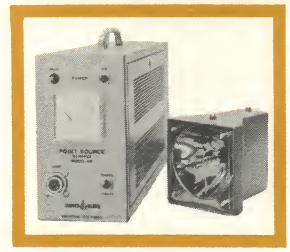


VMS SAMPLERS

are sample/hold units. Commanded by the SLIP-SYNC, they create slow-motion replicas of high frequency signals for oscillograph recording.

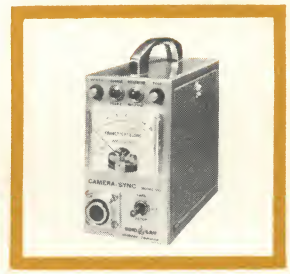
STROBEX

is a very bright white stroboscopic light, with a light-weight and portable lamp unit, and dual intensity for visual and photographic work.



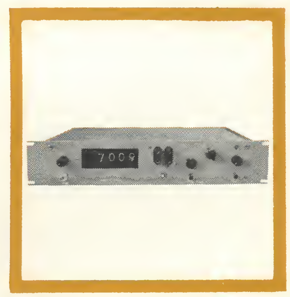
POINT SOURCE STROBEX

has a narrow light beam, two feet in diameter at twenty feet; for intense illumination of smaller objects, for photomicroscopy and for helicopter blade tracking.



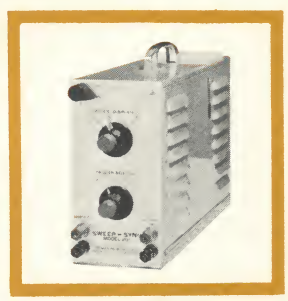
CAMERA-SYNC

is the power source for the PULSE CAMERA, providing AC power and shaping of trigger pulses.



DIGI-MARK

is an electronic counter with electronic readout. It can drive a single galvo in any oscillograph to record an easily read code for test frequency, at counter accuracy.



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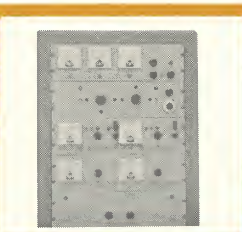

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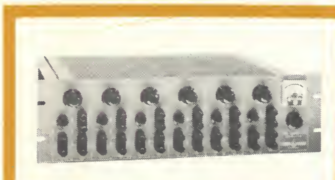

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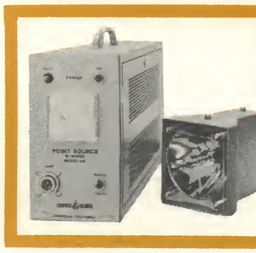

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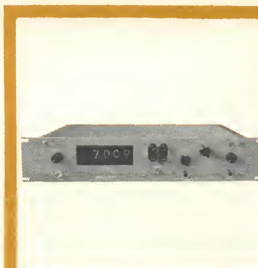

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PULSE CAMERA MAINTENANCE

It has been found necessary to clean the "anti back-up" spring, A, at intervals in order to preserve proper operation as a ratchet type device. This ratchet effect prevents the loss of "wind-up" in the torque spring, B, and the loss of energy this would cause. Since the mechanism is a "tuned circuit" consisting of the spring of the torque spring and the mass (angular) of the shutter mechanism, it is important that the energy stored in the torque spring at the end of each cycle be conserved for use in the next cycle. The motor only adds energy, it does not "brute-force" the mechanism. When the anti-backup spring becomes dirty or gummy, it fails to hold the required wind up.

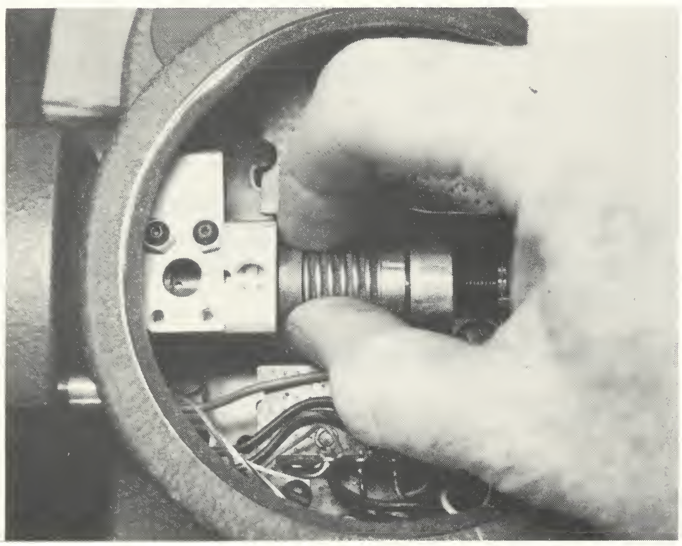

Figure 1

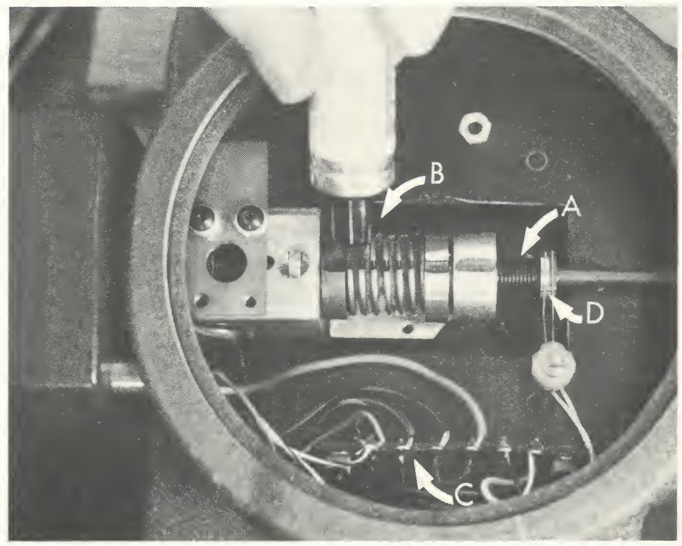

Figure 2

Proceed as follows:

CAUTION - 110 VAC appears on terminal strip C.

1) Remove the 4" door on the side of the camera. Remove snap ring and push door out from opposite side if it won't fall out.

2) If there is no line on mechanism as in figure 2, release mechanism by putting Camera-Sync in "setup" and pushing "Single Frame" button. Then, with switch in "off," rotate input end of torque spring clockwise (looking from motor end) until mechanism stops, as shown in figure 1. Be careful not to put any "wind up" on torque spring by rotating output end beyond this point.

3) Draw a line across all the parts as shown in figure 2.

4) Put Camera-Sync on "Take" and push "Single Frame" button repeatedly. There should be a consistant overshoot of 30° to 60° as shown in figures 3 and 4.

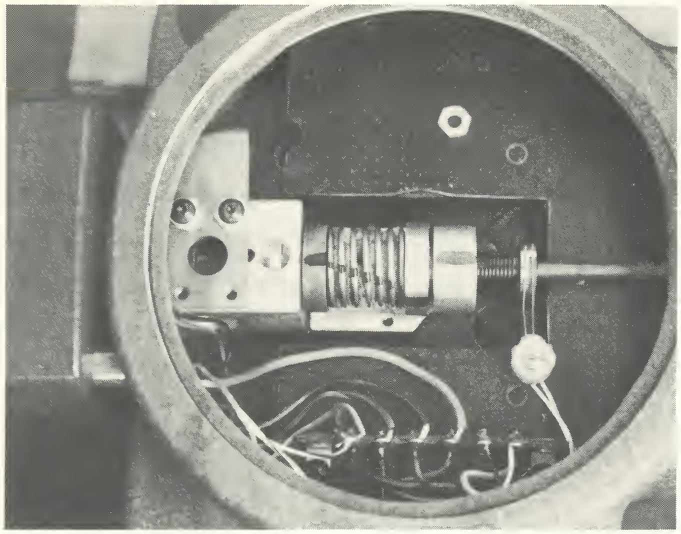

Figure 3

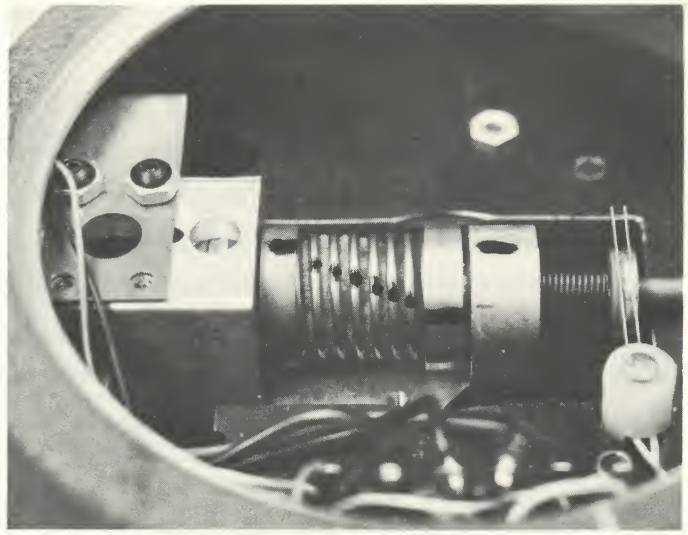

Figure 4

5) If there is not proper overshoot, use a non-oily, non-residue solvent such as Tri Chlor or Chlorothene (lighter fluid is OK but not as good) and, using an eye dropper or pipe cleaner, clean the anti-backup spring B. Use generous amounts of solvent, and run the Camera with the "Solenoid Release" button depressed while applying the solvent.

6) This should restore the overshoot, which can be verified by repeating procedure in paragraph 4.

7) If operation is still not correct, check with the factory.

The function of the commutator-shorting switch D which appears on the newer Cameras is to provide a certain indication of malfunction. If the overshoot is improper, or the frame rate too high, or if for any reason a pulse occurs while the shutter is closed and the film in motion, the switch will short out that pulse. This also causes the Strobex not to flash, thus providing clear warning that all is not well. If the Slip-Sync is set for too high a frame rate, the switch will cause a "countdown" of its own which will restore proper operation. However, operation of the switch usually means the anti-backup spring needs attention as described above, assuming the Slip-Sync has been properly adjusted.

If the system fails to operate when the Camera-Sync is switched to "take," it usually means the Camera has come to rest with the switch in a shorted position, and depressing the "Single Frame" button will by-pass the switch and initiate proper operation.

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MONROVIA, CALIFORNIA

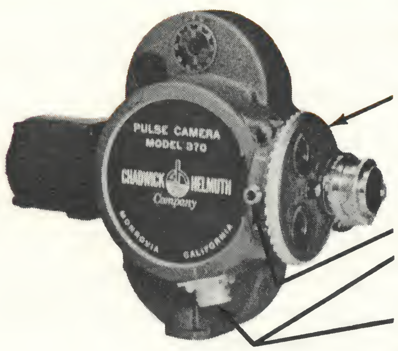
data sheet 370/352

PULSE CAMERA, Model 370, and CAMERA-SYNC, Models 352, 353

The Model 370 PULSE CAMERA is a high frame rate, intermittent-motion pulse camera, loading with 16 mm motion picture film. It requires an electrical command for each film frame, and takes just one frame for each command. With it, synchronized photography is easily accomplished for SLIP-SYNC slow-motion effects, oscilloscope displays, CCTV, computer outputs, or other visual instrumentation. With the SLIP-SYNC system it takes excellent slow-motion movies of high frequency structural resonances in laboratory vibration tests. The PULSE CAMERA is also useful for time-lapse motion pictures, where long duration events are speeded up by slow taking rates and 24 fps playback.

The CAMERA-SYNC is a power source and shaping amplifier for the PULSE CAMERA. It contains appropriate controls for convenient operation.

FEATURES & SPECIFICATIONS — Model 370



Frame Rate: 30 fps max, approx. 24 fps with SLIP-SYNC system.
Film: Standard 16 mm, 100 ft. roll, 4,000 frames per roll, any emulsion readily available.
Lens Mount: Standard "C", 3 lens turret, one 1" f 1.9 lens furnished.
Viewfinder: Parallax correcting type (concealed by lens in this view).
Shutter: 204°, "Normally open" for use with SLIP-SYNC. Easy to reverse to "Normally closed".
Critical Focus: Through-the-lens.
Input Trigger: 35 v dc pulse, 10 millisec, into 140 ohm coil. Supplied by CAMERA-SYNC.
Power: 117 v ac, 60 cps, two phase, as from CAMERA-SYNC.
Size & Weight: 8 x 5 ½ x 10 inches, 7#
Price: $1,850.00

FEATURES & SPECIFICATIONS — Models 352 & 353

Input Trigger (rear): 15 v min + pulse, 200 microsec min, as from SLIP-SYNC, into 25 K ohms.
Single Frame control: For time lapse or single frame advance.
Solenoid Release control: To run leader, or motorized cine photography at 30 fps.
Frame Rate Meter: Scaled 0 to 30 fps.
Take control: For photography.
Setup control: To adjust max pulse rate at SLIP-SYNC without running film.
Output: 2 phase 117 v ac for camera motor, 35 v dc pulse for camera solenoid.
Power required: 117 v ac ± 10%, 35 w, 60 cps only on Model 352. Model 353 takes 117-220 v ac ± 10%, 35 w, from 50 to 400 cps, or 12 v dc, 35 w. on request. All other specs of these models are the same.
Size and Weight: Model 352 (cabinet): 3 ½ x 6 ¾ x 6 ½ inches, 4#
Model 352 R (rack mount): 3 ½ x 19 x 6 ½ inches, 5#
Price: Models 352 and 352R, $333.00 Model 353R, $530.00

Guarantee: one year on materials and workmanship. FOB: Monrovia, Calif., terms net 30 days.

Associated Equipment: TRIPOD, RACKOVER, STROBEX, SLIP-SYNC, REFLECTOR EXTENSION, DIGI-MARK, REMOTE READOUT, STROBEX STAND, ROLLING CONSOLE

CHADWICK HELMUTH
Company

CHADWICK-HELMUTH COMPANY
MONROVIA, CALIFORNIA

data sheet 105A

SLIP-SYNC Model 105A

For the slow-motion study of cyclic events, the SLIP-SYNC commands:

STROBEX stroboscopic lights for visual slow-motion observation.
PULSE CAMERA for 16 mm slow-motion movies.
VMS SAMPLERS. Their slow-motion replicas permit oscillograph recording of phase, distortion, and amplitude of multi-channel high frequency cyclic signals.

For laboratory vibration tests, its input signal comes from the shaker console. For other repetitive or cyclic motion tests a sine wave from a simple transducer supplies input signal. Tach generators, vibration pickups, photocells, and proximity pickups can be used. Types of transducers and connections will be recommended by our engineering department.

FEATURES AND SPECIFICATIONS

Input (rear): sine wave at test frequency, from 5 cps to 10kc. Response to frequency sweep is instantaneous, and transient recovery time is 1 cycle of input. Z_{in} 500K.

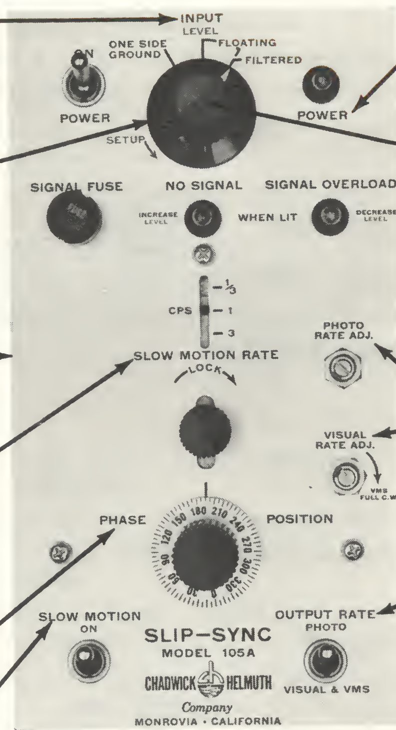
Input Selection: "One Side Ground" for audio oscillator; "Floating" for rotary power supplies.

Light blue "splatter" finish. Both sides removeable for easy access. Hand soldered etched wiring gives compactness and exceptional reliability.

Adjustable between ⅓ and 3 cps to suit individual preference for search or study, or to match VMS to shaker sweep rate

Frozen image can be positioned anywhere in its cycle, from 0 to 360°

"Off" for frozen image, "On" for slow-motion image.



117 vac, ± 10% 50-60 cps, 100 watts. 220 vac avail. on special order at no extra charge.

Control for centering 100:1 (40 db) input amplitude range within the limits 0.3 to 1,000 volts rms. 60 cps signal avail. in "Setup".

+ output pulse (rear): 15 v peak trigger pulse for STROBEX, PULSE CAMERA, or VMS SAMPLERS

Controls for automatic circuit, dividing the output pulse rate so that it does not exceed:
200 pulses/sec for VMS, and for STROBEX, visual
24 pulses/sec for PULSE CAMERA photography
Once set, no further attention is required over entire shaker frequency range.

2 ac outlets, and condensed installation and operating instruction, on rear.

Model	Mounting	Width x Height x Depth			Weight	Price*
105A	Portable Cabinet	5 ½	10	16	24#	$870
105AR	Relay Rack	19	7	16	28#	$870
		(14 depth behind panel)				

*Terms net thirty days, FOB Monrovia, Calif.

Guarantee: One year on materials and workmanship, except tubes.

Associated equipment: STROBEX, PULSE CAMERA, CAMERA-SYNC, VMS SAMPLERS, DIGI-MARK, SINE-MAKER, SWEEP-SYNC, DATA SWITCH, ROLLING CONSOLE

REPRESENTED BY:

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